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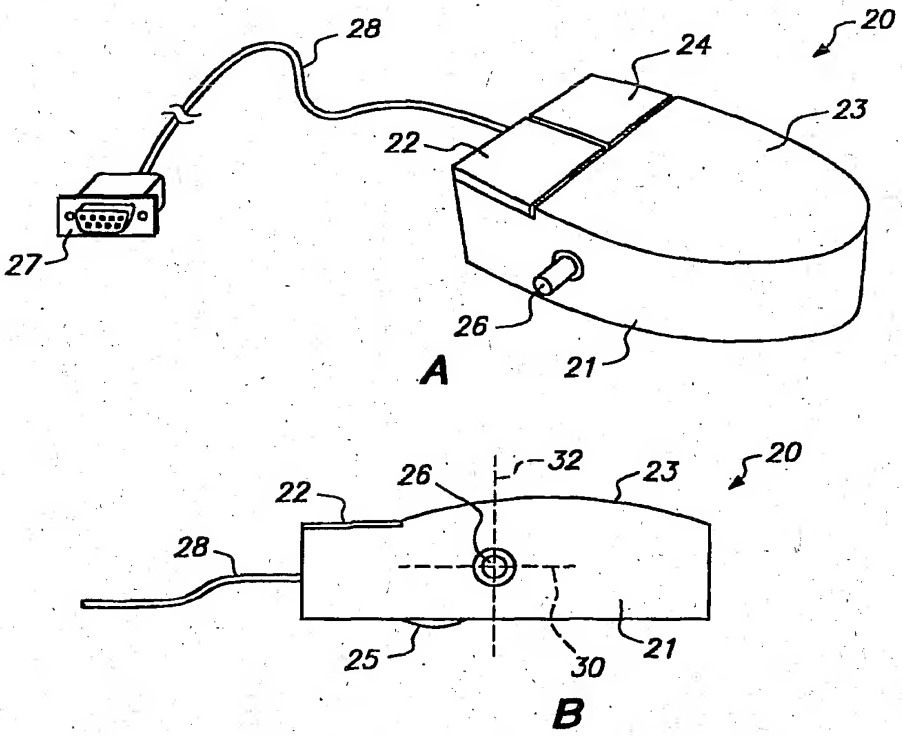
(57) Abstract

An input device for use with a computer, and methods of use, are provided which enable a user to specify the motion of a cursor on a computer display, and to specify a variety of parameters, including binary parameters and a continuous two–dimensional parameter. In a first embodiment, a strain–sensitive two–axis control stick, used for specifying the continuous two–dimensional parameter, is disposed on a lateral surface of a "mouse"–style pointing device. A rolling ball mechanism is used to detect the motion of the device, which determines the motion of the cursor. Push–buttons disposed on a top surface of the device are used to specify binary parameters and activation of commands or actions. Alternative embodiments include a variety of alternative mechanisms for specifying the continuous two–dimensional parameter, and alternative placements of these mechanisms.



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APPARATUS AND METHODS FOR MOVING A CURSOR ON A COMPUTER DISPLAY AND SPECIFYING PARAMETERS

Field Of The Invention

The present invention relates to computer input devices and methods of use for specifying the motion of an object or cursor on a computer display, and to specify simple software control parameters.

Background Of The Invention

There are many known input devices for controlling the motion of a cursor on a computer display. Input devices used for this purpose are referred to as pointing devices, and include keyboards, keypads with specialized cursor control buttons, light pens, joysticks, tablets, trackballs, trackpads, and mice. In addition to enabling a user to move an object or cursor, these devices enable a user to specify simple parameters, such as object selection or deselection, selection of items from a menu, or activation of commands or actions. The method used for specifying such parameters varies according to the device, but typically involves moving the cursor to a location on the display associated with the parameter to be specified, and then pressing a button attached to the device.

Currently, the most popular pointing device is a hand held device called a mouse, which the user moves across a flat surface to control the motion of a cursor on a computer display. A typical mouse has between one and three buttons, also called mouse buttons, located on its top surface, that are used for selecting or deselecting items on the display, activating menu items on the display, and other simple tasks.

To perform more complicated tasks, or specify parameters that are more complex than the simple on/off (binary) parameters which are easily specified through use of buttons, an operator of a typical mouse must perform cumbersome multi-step procedures, or use awkward combinations of mouse buttons, mouse movement, and keyboard keys to modify the mouse operation. For example, an operator may have to press two mouse buttons simultaneously, or may have to press the "Alt" and "Shift" keys on a computer keyboard while pressing a mouse button twice in rapid succession.

There are many situations in which it is necessary to perform such complex operations. For example, in many drawing applications, the drawing may be too large to display in its entirety, so only a portion of the drawing is displayed. To change the displayed portion of a drawing an operator of a display program accepting input from a previously known mouse must undertake a complex series of steps. First the mouse is used to move the cursor to a position on the display corresponding to a "move" or "drag" tool, which is then selected using one of the mouse buttons. The operator then uses the mouse to move the cursor into the area of the screen on which the drawing is displayed, presses one of the mouse buttons, and moves

the mouse while holding down the button to reposition the drawing. Alternatively, the operator may move the cursor into a portion of the display called a "scroll bar." Holding down one of the mouse buttons while the cursor is located in the scroll bar repositions the drawing along a single axis. This operation must be done separately for the X-axis and the Y-axis.

As another example involving windowing operating systems, a user typically keeps a number of objects or "shortcuts" on his "desktop" (the computer display). Previously known pointing devices permit cursor movement within the confines of the displayed desktop, but typically do not permit scrolling to regions outside the desktop. Through use of specialized software, an operator may create a "virtual desktop" which is much larger than the area that can be displayed on the screen. Scrolling the visible region of this "virtual desktop" typically requires that the operator physically move the mouse to position the cursor at the margin of the displayed area.

To reduce the complexity of performing these operations, some manufacturers have added an additional dial or wheel to a top or side surface of a mouse, which may be used to specify one-dimensional parameters. For example, a mouse sold by Microsoft Corporation, Redmond, Washington, under the trademark "INTELLIMOUSE" includes a wheel mounted on its top surface, which may be used to scroll documents and drawings along a single axis at a time.

Such devices, however, do not significantly reduce the complexity of performing two dimensional operations, such as scrolling simultaneously along two axes, or performing zooms, pans, or rotations in two dimensions in CAD (Computer Aided Design) programs. To

perform tasks in which more than one continuous parameter must be controlled simultaneously, complex procedures similar to those used on previously known mice must be employed.

It would therefore be desirable to provide a pointing device and methods of use that facilitate two dimensional movement, such as scrolling a virtual desktop along two axes, without requiring extensive physical movement of the pointing device, or repositioning of the cursor.

It would also be desirable to provide a pointing device and methods of use which enable an operator to control two continuous parameters simultaneously, without extensive physical movement of the pointing device, or repositioning of the cursor.

Summary Of The Invention

In view of the foregoing, it is an object of the present invention to provide a pointing device and methods of use that facilitate two-dimensional movement without requiring extensive physical movement of the pointing device or repositioning of the cursor.

It is also an object of the present invention to provide a pointing device and methods of use which allow an operator to specify a continuous two-dimensional parameter, or two continuous one-dimensional parameters, without requiring extensive physical movement of the pointing device or repositioning of the cursor.

These and other objects of the invention are accomplished by providing a pointing device including an additional two-axis control. In a preferred embodiment, an improved pointing device is provided that enables an operator to control the position of an

object or cursor, provides binary parameters using push-buttons or switches, and further provides a two-dimensional parameter using a strain-sensitive two-axis control stick, in which the two axes of the control stick correspond to two dimensions of the two dimensional parameter to be controlled.

Alternatively, the pointing device of the invention may use a control pad or a miniature trackball as a two-axis control, instead of a control stick. The control pad or miniature trackball may be disposed on a lateral face of the pointing device, so that an operator can easily manipulate it with his or her thumb.

In another alternative embodiment of the present invention, two-axis controls may be disposed on two lateral surfaces of the pointing device, or on a top surface between the buttons, so that the two-axis control may be manipulated with equal ease by right-handed or left-handed users.

Brief Description Of The Drawings

The above and other objects of the invention will be apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which like reference characters refer to like parts throughout, and in which:

FIGS. 1A and 1B show, respectively, a perspective and a side view of a first illustrative embodiment of a pointing device constructed in accordance with the present invention;

FIG. 2 shows a block diagram of the circuitry of the pointing device of the present invention,

indicating the flow of information between the parts of the pointing device;

FIGS. 3A, 3B, and 3C are perspective views of alternative embodiments of the pointing device of the present invention; and

FIGS. 4-8 are illustrative software applications that accept the commands from a pointing device constructed in accordance with the principles of the present invention.

Detailed Description Of The Invention

Referring to FIGS. 1A and 1B, an illustrative preferred embodiment of a hand-held pointing device constructed in accordance with the present invention is described. Pointing device 20 includes push-buttons 22 and 24 on top surface 23 for specifying binary parameters and activating commands or actions, X-Y positioning mechanism 25 located on the bottom surface of the device (visible in FIG. 1B), strain-sensitive, thumb-actuated, two-axis control stick 26 (referred to hereinafter as a thumbstick) for specifying a two-dimensional parameter, and interface 28 to a computer (not shown).

In the illustrative embodiment of FIGS. 1, thumbstick 26 is disposed on lateral surface 21 of pointing device 20, thereby allowing an operator to apply varying force along thumbstick axes 30 and 32, shown in FIG. 1B. The force exerted along axes 30 and 32 is measured by orthogonal pairs of stress transducers internal to the pointing device (not shown). Signals from the orthogonal pairs of stress transducers provide information on the magnitude of force along both axes, indicating a degree of activation of thumbstick 26. This enables an operator

to continuously specify a two-dimensional parameter, or to simultaneously specify two one-dimensional parameters by exerting force on thumbstick 26 in the directions of right/left axis 30 or up/down axis 32. As will of course be understood, thumbstick 26 may have varying force applied in any direction, and will generate a signal having corresponding components along axes 30 and 32.

In addition to enabling specification of parameters using thumbstick 26, pointing device 20 enables an operator to specify the motion of a cursor on a computer display and to specify binary parameters. The binary parameters are specified by depressing push-buttons 22 and 24 disposed on top surface 23 of pointing device 20. Push-buttons 22 and 24 may also be used to activate commands or actions, and may comprise any suitable button or switch mechanism.

Two-dimensional cursor motion information is specified in a manner similar to a conventional mouse-style pointing device. The X-Y positioning mechanism translates the motion of the pointing device across a flat surface into cursor motion on a computer display which is proportional to the physical motion of the device.

A variety of methods are known for detecting the motion of a mouse-style pointing device across a surface. In a preferred embodiment of the present invention, the X-Y positioning mechanism comprises rolling ball mechanism 25, located on the bottom surface of the device (see FIG. 1B), which is used to translate the device's motion in two orthogonal directions into an output signal. A similar mechanism is used in mouse-style pointing devices sold commercially by numerous vendors, including Microsoft

Corporation of Redmond, Washington, and Logitech, Inc. of Fremont, California. One implementation of such a mechanism is described in detail in U.S. Patent Number Re. 32,632, to Atkinson, which is incorporated herein by reference. It will be apparent to those skilled in the art that other X-Y positioning mechanisms, such as optical sensors or gyroscopes, may also be used with the present invention to detect the motion of the pointing device.

In a preferred embodiment of the present invention, pointing device 20 interfaces with a PC-compatible computer using a standard EIA-232 serial interface with DB-9 connector 27. Alternative preferred embodiments may be interfaced to a variety of current computers using well-known interface standards, such as an Apple Desktop Bus interface (Apple Computer, Inc., Cupertino, California) or a PS/2-style serial interface (International Business Machines, Inc., Armonk, New York). The present invention may be interfaced to virtually any computer using a suitable interface. For example, wireless interfaces using infrared or radio technologies, such as those sold commercially by Logitech, Inc., of Fremont, California may be used to transmit data between the computer and pointing device 20.

FIG. 2 is a block diagram showing the flow of information in an illustrative embodiment of the present invention. Signals generated by push-buttons 22 and 24, X-Y positioning mechanism (rolling ball) 25, and thumbstick 26 are fed into processor 38. Processor 38, which may be, for example, a PIC16CXXX family microcontroller, manufactured by Microchip Technology Inc., Chandler, Arizona, translates these signals into a computer-readable signal using A/D converters, timing

information, direct digital inputs, or other means, depending on the signal being translated. Processor 38 then sends a computer-readable signal to a host computer through interface 28. These computer-readable signals may be sent when the computer demands them (polled mode), when there is significant change in the signals monitored by the processor, or at regular intervals, depending on the needs of the computer with which the device is interfaced. The processor may also receive commands from the computer through interface 28, and respond to those commands.

In accordance with the principles of the present invention, other two-axis controls may be substituted for the thumbstick of FIGS. 1A and 1B. For example, FIG. 3A depicts an alternative embodiment in which directional control pad 40, similar to those found on input devices used with video game console systems, is disposed on lateral surface 21 of pointing device 20. When an operator presses on part of directional control pad 40, switches or transducers beneath the pad provide processor 38 with signals indicating the degree of activation of the control pad along its two axes.

In FIG. 3B, miniature trackball 42 is disposed on lateral surface 21 of the pointing device. Using methods similar to those employed to detect the motion of rolling ball X-Y positioning mechanism 25, the motion of miniature trackball 42 in each of two orthogonal directions may be detected, and signals indicative of this motion may be sent to the processor. The degree of activation of miniature trackball 42 is determined by the speed at which an operator turns it in each of the two orthogonal directions.

In FIG. 3C, thumbstick 26 of pointing device 20 has been relocated from lateral surface 21 of input device 20 to top surface 23. This change allows thumbstick 26 to be operated with equal ease by both right and left-handed operators, using the index finger. It will be apparent that any of the foregoing two-axis control devices described hereinabove may be disposed on top surface 23 of the pointing device. It will also be apparent that any of the input mechanisms disposed on the device (i.e. the push-buttons, the two-axis control, or the X-Y positioning mechanism) could be relocated to positions on the device other than those shown in the figures.

Applicant contemplates that there are many potential applications for a pointing device constructed in accordance with the present invention. Plainly, pointing device 20 may be used in the same manner as previously known mice; allowing an operator to position a cursor or object on a computer display, and to specify simple binary parameters. Pointing device 20 may also be used in a mode where only one of the two axes of two-axis control 26 is employed. This one-axis mode could be used, for example, to continuously specify a speed at which a cursor on a computer display moves in response to movement of X-Y positioning mechanism 25. Importantly, however, information provided by two-axis control 26 may be used for numerous additional applications which heretofore could not easily be accomplished with previously known mouse-style pointing devices. A few of these applications are described below.

Windowing Applications

In windowing operating systems such as Windows 3.1 or Windows 95, sold by Microsoft Corporation, Redmond, Washington, the computer display typically represents a "desktop." The desktop typically displays a number of objects representing programs, and may include windows containing applications, menus, and other items being used by an operator. Since the desktop area generally displays all of the activities available on the system, it is desirable for the desktop area to be as large as possible, so that many activities may be displayed simultaneously. Using specialized software, it is possible to create a "virtual desktop" that is larger than the area which may be shown on the computer display. When the desktop is larger than the area that can be displayed, it may become necessary to "scroll" the desktop to reveal portions which are outside the area shown on the display.

With respect to FIG. 4, one application of pointing device 20 is described in which the two-axis control is employed to scroll within a virtual desktop that is larger than area 52 that can be displayed. Virtual desktop 50 contains numerous windows 56, which may only be viewed when they are within the displayed portion of desktop 50. In accordance with the principles of the present invention, the displayed portion of desktop 50 (within area 52) may be scrolled in a direction and at a speed indicated by the operator through use of the two-axis control. Movement of cursor 54 within area 52 of the display is controlled using X-Y positioning mechanism 25 of the invention, independent of the scrolling of desktop 50. For example, cursor 54 may remain stationary while the two-

axis control is used to scroll desktop 50 with respect to cursor 54. By comparison, previously known methods for scrolling on a virtual desktop typically require that the pointing device be repositioned to move the cursor to an edge of the display to indicate the direction in which the desktop should be scrolled.

A further advantage of the pointing device of the present invention is described with respect to FIG. 5. Instead of having a single desktop, the system is programmed to provide two-dimensional array 60 of desktops 62, each representing a "neighborhood" of similar activity, and each possibly containing numerous windows 56. The operator may select which of these desktops 62 is shown on the display by using the two-axis control to switch between them. By pressing up on thumbstick 26, for example, the operator may indicate that he wants to display desktop 62a above the current desktop 62b in array 60. As in the application described with respect to FIG. 4, the movement of cursor 54 is completely independent of the selection of the displayed desktop, while movement within the desktop is accomplished using X-Y positioning mechanism 25.

Menu Selection Applications

The two-axis control of pointing device 20 may be advantageously used to select options from a multi-level menu. In FIG. 6, a "rolling" menu system is depicted, in which one of the axes of the two-axis control is used to specify which of menus 64 will be used, while the other axis is used to rotate though menu items 66 to place a specific item from a selected menu beneath highlight indicator 68. For example, by operating the two-axis control along right/left axis

30, the operator switches between menus 64, only one of which is displayed at a time. When a desired menu is displayed, the operator then uses up/down axis 32 of the two-axis control to cause items 66 in the menu to roll up and down beneath highlight indicator 68. Once the desired item is highlighted, one of push-buttons 22 and 24 is actuated to select the item. Advantageously, the cursor need not be moved to make menu selections in accordance with this aspect of the invention.

Drawing Program Control

In another application of pointing device 20, the ability of the two-axis control to specify two one-dimensional parameters may be used to control two separate attributes of objects, such as a rectangles, lines, ellipses, or curves, in a drawing program. For example, FIG. 7 shows line 70 in a drawing program, in which one axis of the two-axis control is used to continuously vary the line thickness, while the other axis is used to select a line style (e.g. solid, dotted, dashed, etc.). Any two one-dimensional attributes, such as selection of color from a list, rotation around a single axis, fill style, line thickness or line style may be selected using the two-axis control. As in the foregoing applications, using this method allows program attributes to be selected without repositioning the pointing device or moving the cursor.

With respect to FIG. 8, an application of pointing device 20 to manipulate objects in three-dimensional drawing and display software is described. In this application X-Y positioning mechanism 25 is used to move three-dimensional object 80 in the plane of the display, while the right/left and up/down axes

of the two-axis control are used to specify the rotation of object 80 around axes 82 and 84 respectively.

* * *

The foregoing applications demonstrate that pointing device 20 may be advantageously used to specify a two dimensional parameter, or two one-dimensional parameters, in addition to specifying the position of a cursor and simple binary parameters. A pointing device constructed in accordance with the principles of the present invention provides capabilities heretofore unavailable with previously known pointing devices.

It will be apparent to one of ordinary skill in the art that there are many changes which may be made, such as changing the number or placement of the controls, changing the X-Y positioning mechanism used, changing the interface, or changing the applications for which the device is used, that fall within the scope of the present invention. Although the present invention has been described with reference to FIGS. 1-8, it is understood that the figures are for purposes of illustration only, and not of limitation, and that the invention is only limited by the claims that follow.

What Is Claimed Is:

1. An input device for use with a computer, the input device having an X-Y positioning mechanism for detecting movement of the input device in first and second orthogonal directions, a push-button for specifying a binary parameter, a processor coupled to the X-Y positioning mechanism and the push button, the processor programmed to provide a first signal responsive to a status of the X-Y positioning mechanism and a second signal responsive to the push-button, and an interface for transmitting the first and second signals from the processor to the computer, the improvement comprising a two-axis control disposed on the input device, the two-axis control coupled to the processor, the processor programmed to provide a third signal responsive to a degree of activation of the two-axis control.

2. The input device of claim 1 wherein the two-axis control comprises one of a strain-sensitive control stick, a directional control pad, or a miniature trackball.

3. The input device of claim 1 wherein the first signal is used to control motion of a cursor on a display of the computer.

4. The input device of claim 1 further comprising a housing containing the X-Y positioning mechanism, push-button and two-axis control, the two-axis control disposed on a lateral face of the housing.

5. The input device of claim 1 further comprising a housing containing the X-Y positioning mechanism, push-button and two-axis control, the two-axis control disposed on a top surface of the housing.

6. A programmed application for use on a computer in combination with the input device as defined in claim 1, the programmed application comprising:

program instructions for defining a virtual desktop, the virtual desktop having an area larger than a display area of the computer;

program instructions for accepting the first signal to control the motion of a cursor within the display area of the computer; and

program instructions for accepting the third signal to determine a portion of the virtual desktop to be shown in the display area of the computer.

7. The programmed application of claim 6 wherein the portion of the virtual desktop to be shown in the display area of the computer is determined by using the third signal to scroll the virtual desktop with respect to the cursor.

8. The programmed application of claim 6 wherein the virtual desktop is organized into neighborhoods, each neighborhood comprising a portion of the virtual desktop which can be shown in the display area of the computer.

9. The programmed application of claim 8 wherein the portion of the virtual desktop to be shown

in the display area of the computer is determined by using the third signal to switch between neighborhoods.

10. A programmed application for use on a computer in combination with the input device as defined in claim 1, the programmed application comprising:

program instructions for drawing under user control a variety of drawing objects on a computer display;

program instructions for accepting the first signal to control the motion of a cursor within the computer display, the cursor being used to select commands within the programmed application, and to specify the position, size and shape of the drawing objects;

program instructions for accepting the second signal to specify selection of commands for the programmed application, and selection of drawing objects on the display; and

program instructions for accepting the third signal to control a set of attributes of selected drawing objects.

11. The programmed application of claim 10 wherein the drawing objects of the application program are three-dimensional, and the cursor is used to specify the position, size and shape of the drawing objects in three dimensions.

12. The programmed application of claim 10 wherein the attributes controlled by the third signal include rotation of the drawing objects around an axis in a simulated three-dimensional space.

13. A programmed application for use on a computer in combination with the input device as defined in claim 1, the programmed application comprising:

program instructions for defining a multi-level menu structure, containing a plurality of top-level menus, each of which contains a plurality of menu items representing commands or actions;

program instructions for accepting the third signal, a first value of the third signal causing selection of a top-level menu from the plurality of top-level menus, and a second value of the third signal specifying a menu item from the plurality of menu items associated with the selected top-level menu; and

program instructions for accepting the second signal to select specified menu item selected responsive to the third signal.

14. The programmed application of claim 13 wherein the menu items associated with the selected top-level menu rotate up or down with respect to a highlighted area on the computer display, the highlighted area used to specify selection of a menu item.

15. A method of operating a programmed application executing on a computer, the method comprising steps of:

providing an input device that generates a first signal responsive to movement of an X-Y positioning mechanism, the X-Y positioning mechanism detecting motion of the input device in first and second orthogonal directions, a second signal responsive to a status of a push-button, and a third

signal responsive to a degree of activation of a two-axis control;

providing program instructions that accept the first, second and third signals;

actuating the input device to selectively generate the first, second and third signals;

adjusting a location of a cursor in a display area of the computer responsive to the first signal;

selecting a value from a series of values responsive to the second signal; and

selecting a parameter of the programmed application responsive to the third signal.

16. The method of claim 15 wherein the method further comprises a step of:

providing program instructions for defining a virtual desktop, the virtual desktop having an area larger than the display area, the program instructions using the first signal to control the motion of a cursor within the display area, the step of selecting a parameter of the programmed application responsive to the third signal comprising a step of using the third signal to determine the portion of the virtual desktop viewable in the display area.

17. The method of claim 16 wherein the step of using the third signal to determine the portion of the virtual desktop viewable in the display area comprises a step of using the third signal to scroll the virtual desktop with respect to the cursor.

18. The method of claim 16 further comprising a step of organizing the virtual desktop into neighborhoods, each neighborhood comprising a portion of the virtual desktop viewable in the display area, the step of using the third signal to determine the portion of the virtual desktop viewable in the display area comprising a step of using the third signal to switch between neighborhoods.

19. The method of claim 15 wherein the method further comprises:

providing program instructions for drawing under user control a variety of drawing objects on a computer display, the program instructions using the first signal to control the motion of a cursor within the display area, the cursor being used to select commands within the programmed application, and to specify the position, size and shape of the drawing objects, the step of selecting a value from a series of values responsive to the second signal comprising using the second signal to specify selection of commands for the programmed application, and selection of drawing objects on the display, and the step of selecting a parameter of the programmed application responsive to the third signal comprising a step of using the third signal to control a set of attributes of selected drawing objects.

20. The method of claim 19 wherein the step of using the third signal to control a set of attributes of selected drawing objects includes a step of rotating the drawing objects around an axis in a simulated three-dimensional space responsive to the third signal.

21. The method of claim 15 further comprising a step of:

providing program instructions for defining a multi-level menu structure containing a plurality of top-level menus, each top-level menu containing a plurality of menu items representing commands or actions, the step of selecting a parameter of the programmed application responsive to the third signal comprising a step of using a first value of the third signal to select a top-level menu from the plurality of top-level menus and a second value of the third signal to specify a menu item from the plurality of menu items associated with the selected top-level menu, and the step of selecting a value from a series of values responsive to the second signal comprises using the second signal to select the menu item specified responsive to the third signal.

22. The method of claim 21 wherein method further comprises a step of providing program instructions causing the menu items associated with a selected top-level menu to rotate up or down with respect to a highlighted area on the display area, the step of using a second value of the third signal to specify a menu item from the plurality of menu items associated with the selected top-level menu comprising a step of aligning a menu item with the highlighted area.

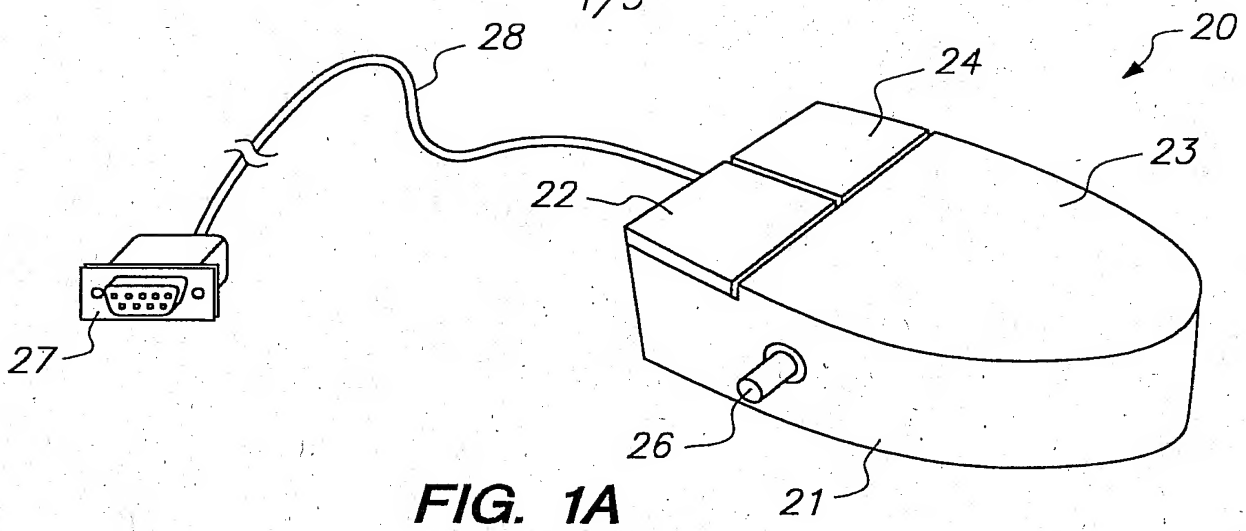

FIG. 1A

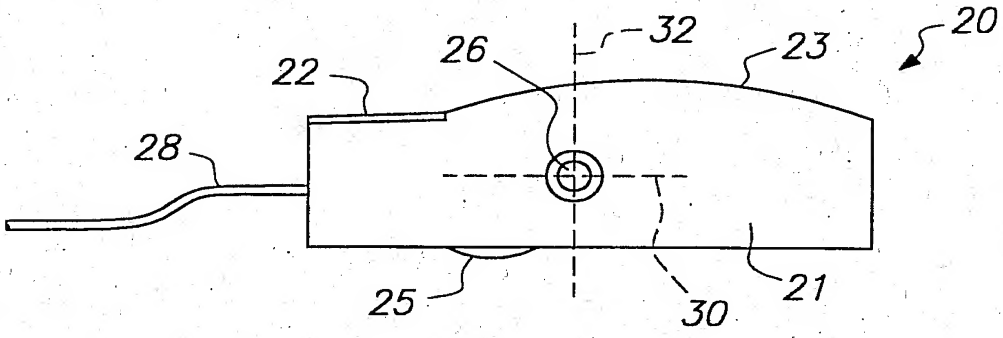

FIG. 1B

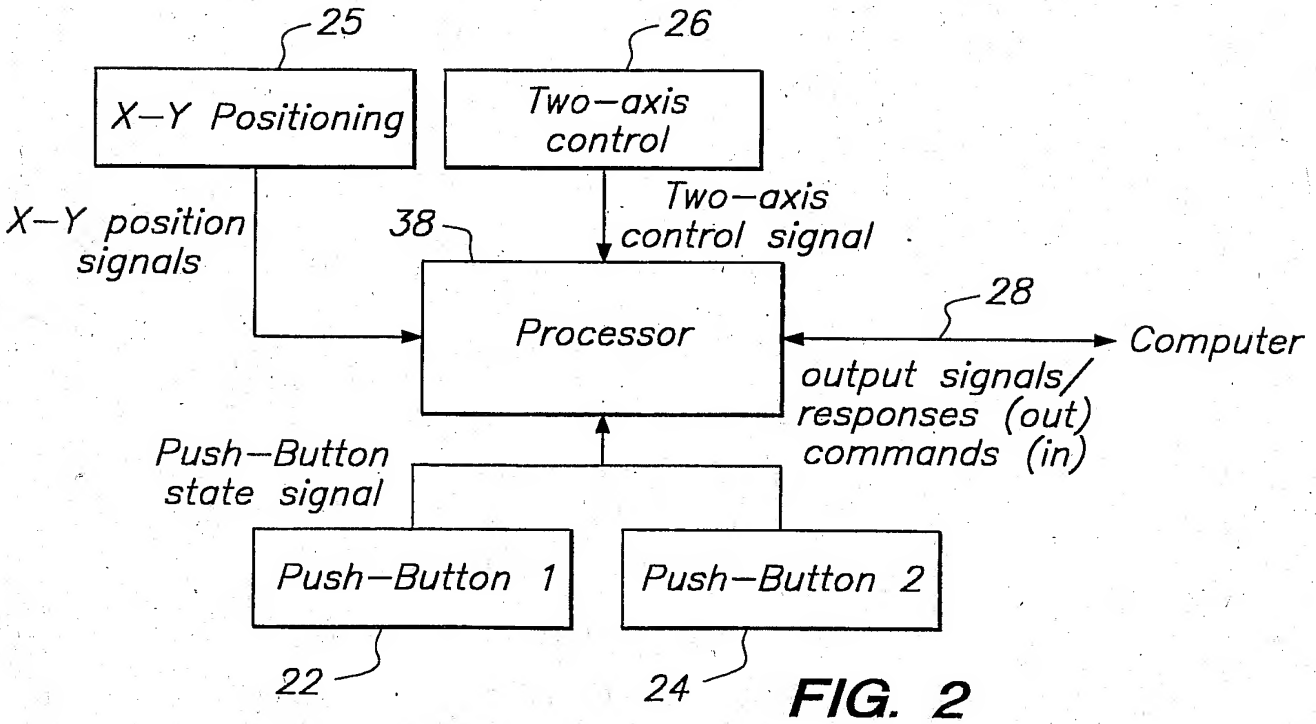

FIG. 2

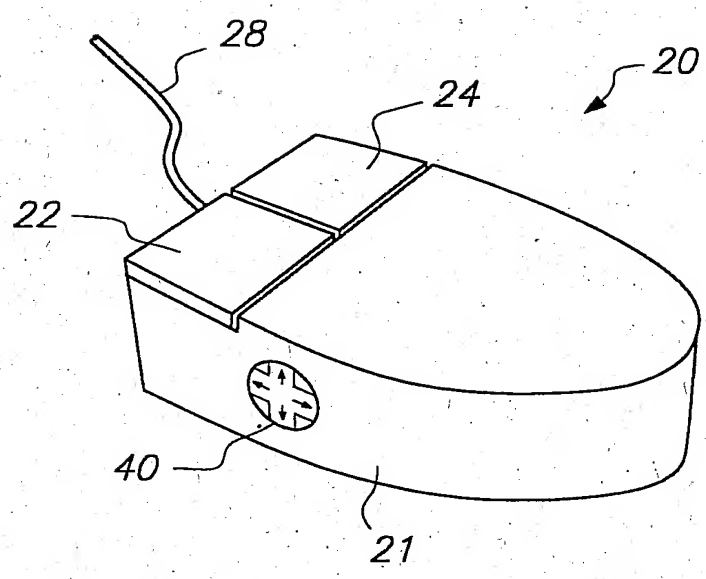

FIG. 3A

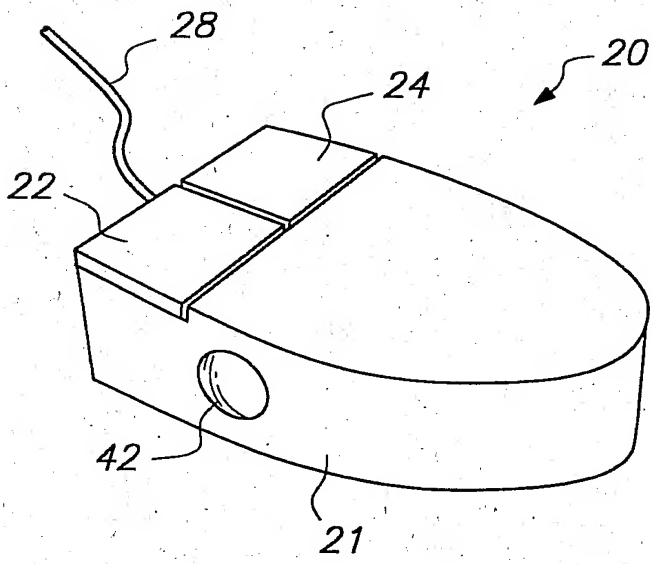

FIG. 3B

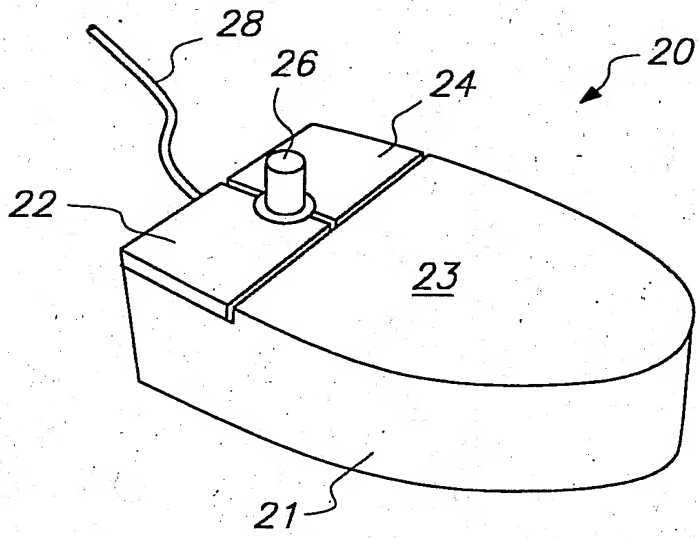

FIG. 3C

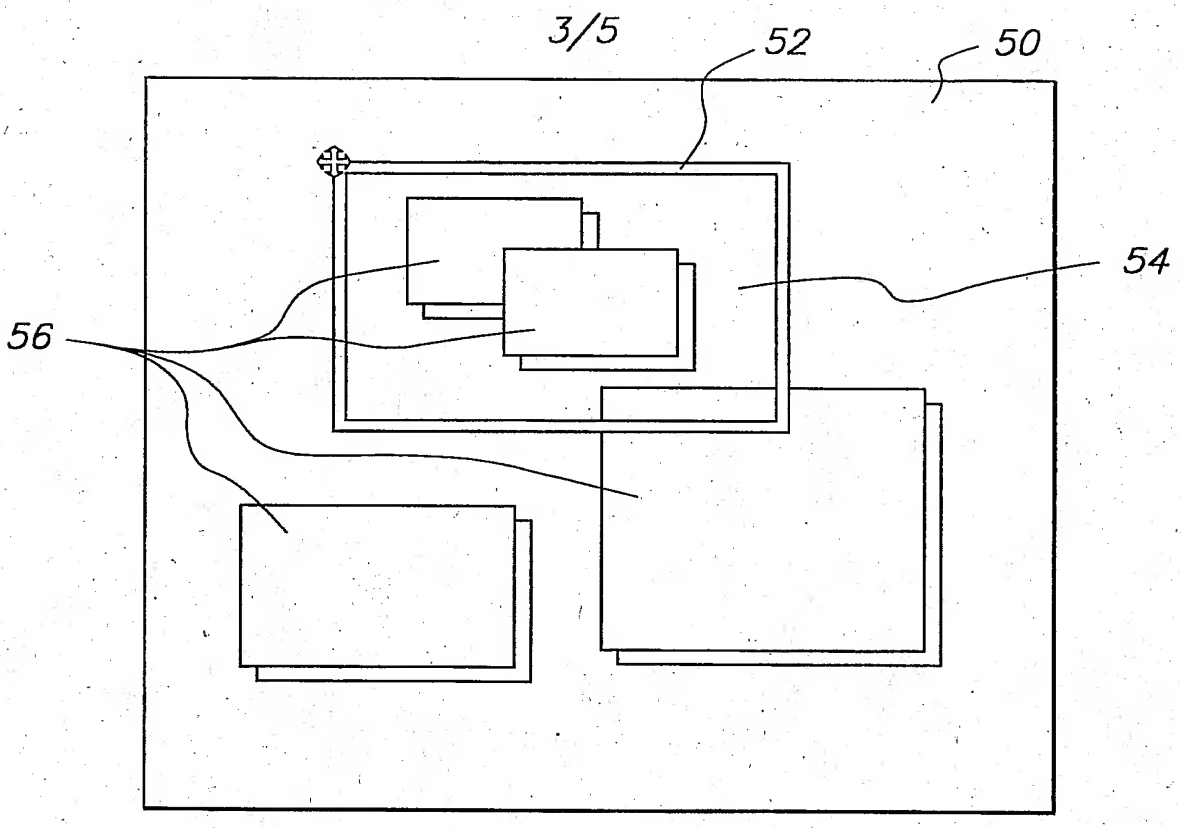

FIG. 4

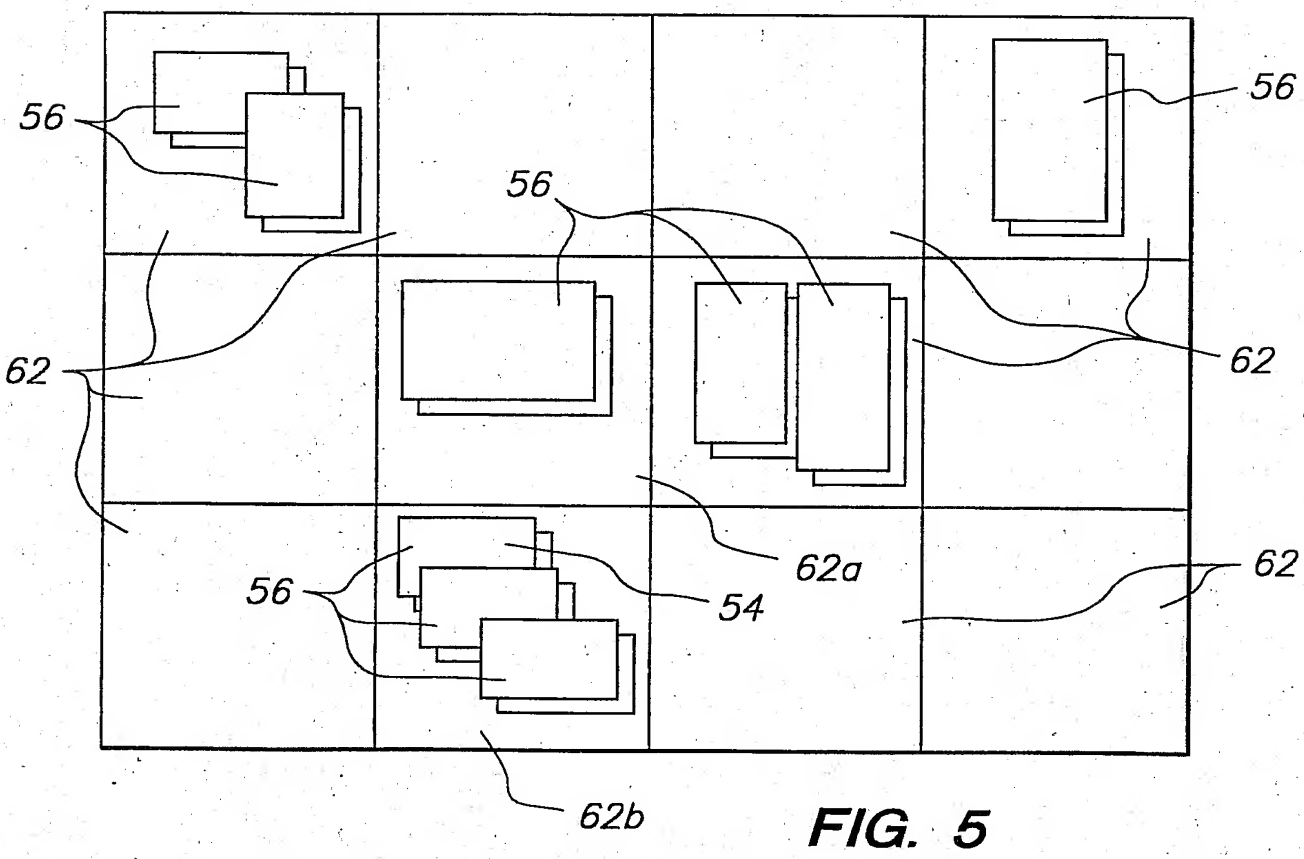

FIG. 5

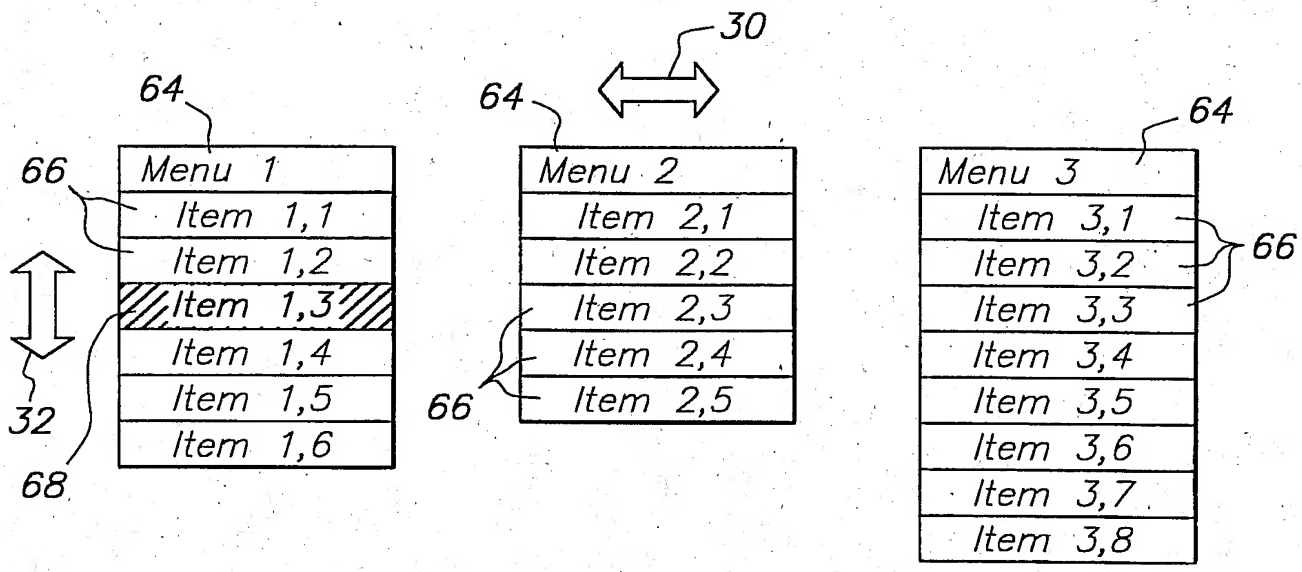
30
64
64
64
66
66
66
32
68
Menu 1
Item 1,1
Item 1,2
Item 1,3
Item 1,4
Item 1,5
Item 1,6
Menu 2
Item 2,1
Item 2,2
Item 2,3
Item 2,4
Item 2,5
Menu 3
Item 3,1
Item 3,2
Item 3,3
Item 3,4
Item 3,5
Item 3,6
Item 3,7
Item 3,8

FIG. 6

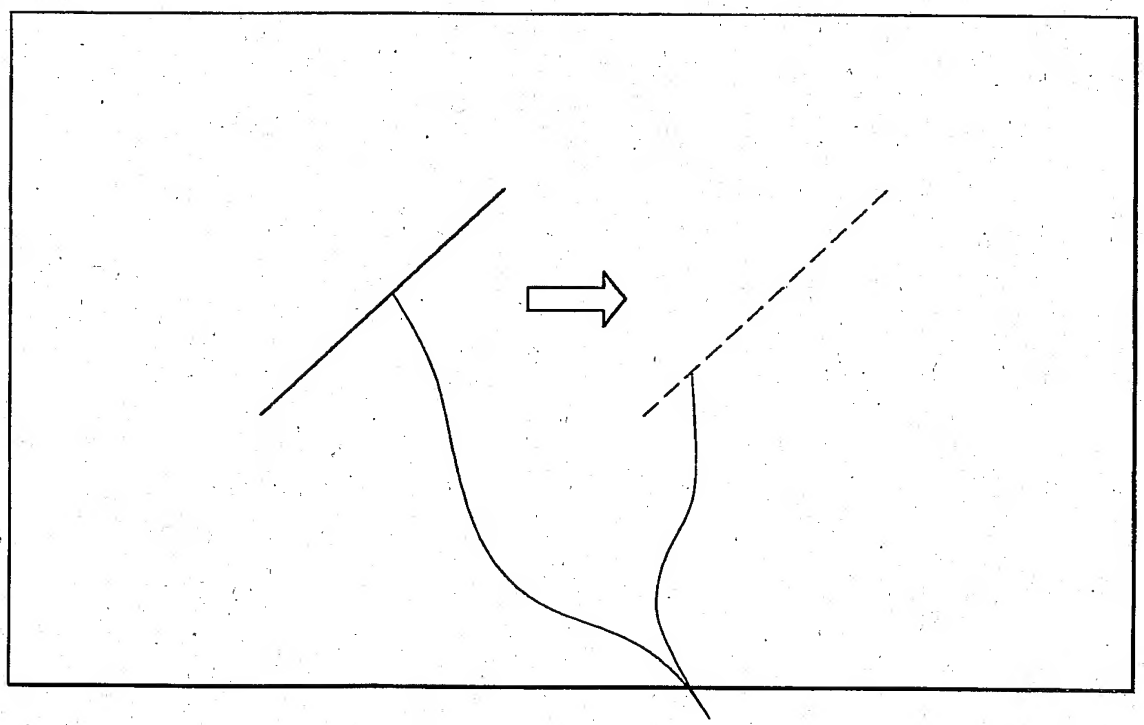
70

FIG. 7

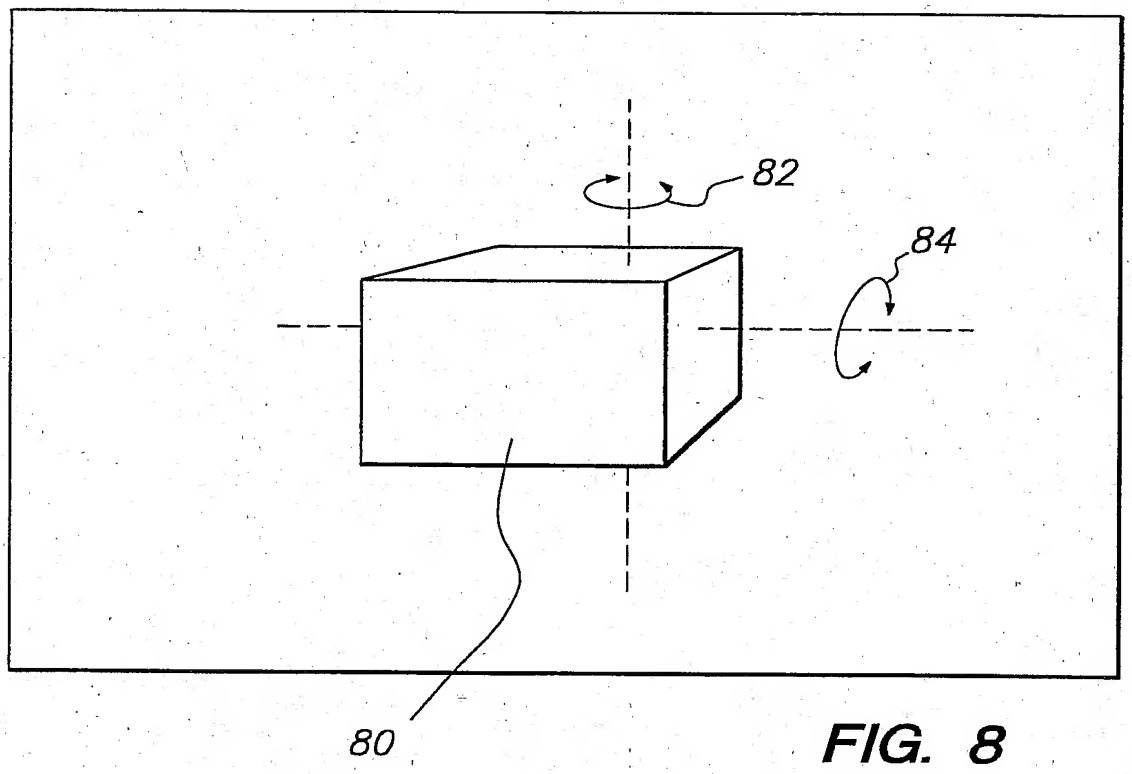

FIG. 8